Reply to Comments by Referee #1

on
BG-2015-506 Effects of climate change and land management on soil organic carbon dynamics and carbon leaching in Northwestern Europe
by M. Stergiadi, M. van der Perk, A.C.M. de Nijs, and M.F.P. Bierkens

We would like to thank the reviewer for his/her comments on the discussion paper, which greatly helped to improve quality of the manuscript. Below we will reply to the points raised by the reviewer.

1. Information on a detailed model parameterization is needed regarding the plant growth, which is one of the main source of C input, influencing SOC, DOC etc.

We added a new paragraph in the model description (2nd paragraph of section 2.1) in which we describe which processes and factor the plant growth submodels in the Century model account for:

> In the Century model, the grassland/crop production submodel simulates plant production for different herbaceous crops and plant communities. The plant production submodel has carbon and nutrient pools for live shoots and roots, and standing dead plant material. Harvest, grazing, fire and cultivation directly affect aboveground biomass, while grazing and fire may also influence root to shoot ratios and nutrient content. At harvest, grain is removed from the system and live shoots can either be removed or transferred to standing dead and surface residue. The forest submodel simulates the growth of deciduous or coniferous forests in juvenile and mature phases. It allocates carbon and nutrients to leaves, fine roots, fine branches, large wood, and coarse roots using a fixed allocation scheme. In both plant production submodels, the monthly plant production is controlled by a maximum production defined for each plant or crop, soil moisture, nutrient supply, temperature, and atmospheric CO2 concentrations. In addition, in the forest submodel, the monthly plant production also depends on the live leaf-area-index and in the grassland/crop production submodel, the monthly plant production is also affected by shading by dead vegetation and seedlings (Metherell et al., 1993).

The model parameter values of the plant growth submodels were borrowed from the default parameter values for a range of crop and forest types, which were provided with the Century model. A sentence explaining this has been added at the end of the first paragraph of section 2.2 (model input and calculations).

2. The present study claimed in the conclusion that "The Century model proved to be a useful tool for modelling past, present, and future SOC contents and DOC concentrations....". The main opportunity of this study to make the future projection more reliable is to compare 'current' model results with present measurements for SOC and DOC. A detailed statistical analysis for model performance is expected. This aspect is weak in the present study. If the measured data or literature values of SOC and DOC from the study region is not available in the top 20 cm soil layer (as needed for model outputs), some depth distribution functions could be useful in model testing. But, still some basic model performance statistics for SOC and DOC are needed within the present time window ('current levels') to make future prediction more reliable.

We agree that a conversion of the measured SOC values to the 20 cm soil depth allows a better comparison between the simulated and observed values. Therefore, we have converted the SOC measurements to the 0-20 cm depths using SOC depth distributions reported by Don et al. (2007) for grassland systems and Braakhekke et al. (2013) for forest systems. In the methods section (at the end of section 2.2), we explain how we converted the observed SOC values to average SOC for the top 20 cm:

> The most important Century model outputs include total average SOC levels, SOC fractionation in different pools in the top 20 cm of the soil profile, and DOC leaching from this soil layer. The DOC concentrations were calculated as annual average flow-weighted concentrations in the leachate. The simulated current SOC levels were compared to observed SOC values derived from various Dutch soil databases for the different land use types and soil types (Province of Noord–Brabant, 1996; Bodemdata, 2014; RIVM, 2014), taking into account the different soil depths the simulated and observed values referred to. For this correction for different soil depths, we converted the observed values for grassland and forest sites using SOC depth distribution data reported for grasslands (Don et al., 2007) and forests (Braakhekke et al., 2013) in Germany and the Netherlands. The observed SOC values for arable were not converted since the SOC distribution within the soil profile of arable land systems can be assumed to be quite homogenous in the top 20 cm of soil due to ploughing (De Bakker, 1979).

In addition, we have added the basic model performance statistics (mean bias error, root mean square error, and Pearson's correlation coefficient) in section 3.2. We have modified the paragraph in section 3.2, in which we describe and discuss the results of the comparison between the simulated and corrected observed values:

> Comparison between the simulated SOC levels and observed values corrected for the differences in sampling depths (Table 5) shows that the Century model underestimated the observed SOC levels. Only the simulated SOC values for the loamy arable land system and the sandy forest system are within the measured ranges. For all considered systems, the mean bias error (MBE) of the model predictions relative to the medians of the observed SOC contents is -0.53% (i.e. g 100 g-1), the root mean square error (RMSE) is 0.88%, and the Pearson's correlation coefficient (r) equals 0.35.

3. Again, model could be adjusted on the basis of the 'current levels of SOC and DOC' to predict SOC and DOC under future climate and land management scenarios more accurately. This step is important for future projection and needs to be considered carefully.

We agree that adjusting the model results on the basis of observed current SOC and DOC levels would perhaps increase the accuracy of the future predictions of the absolute SOC and DOC levels under the various climate and land management scenarios. However, the aim of our study is "to assess the effects of climate change and land management on SOC accumulation, SOC distribution across different pools and DOC leaching". We primarily focussed our results description and discussion on the *changes* in SOC and DOC under the future scenarios. By equilibrating the model and taking the land use history of the modelled systems into account we ensured that the simulated current levels are consistent with the rates of the many simulated processes that control the SOC and DOC levels. By adjusting the simulated values to the observed values (which also show a considerable variation), the initial conditions for the 2013-2100 simulation period would become inconsistent with the process rates. This would make it difficult to distinguish between the effects of climate change / land management on SOC and DOC levels and the effects that result from these inconsistencies. For this reason, we have not adjusted the model results to the observed levels.

4. Future climate change scenario is incomplete without addressing the issue of change in atmospheric CO2 concentration and its effect on plant growth, C input and SOC etc

In fact, we took the increase in atmospheric CO_2 concentrations into account in the Century model scenarios, but we did not mention this in the discussion paper. To better inform the reader about this, we added a sentence in section 2.3.1 (Climate change scenarios) in which we state that we assumed an increase of the atmospheric concentration to 700 ppm in 2100 for both scenarios. To address the effect of this increase relative to other factors, however, was beyond the scope of this study. The fact that the Century model accounts for atmospheric CO_2 concentrations has already been mentioned in the newly added paragraph in section 2.1 about the description of the plant submodels of the Century model (see comment no. 1).